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SMUTS OF WHEAT AND RYE AND THEIR CONTROL

Cereal Smuts Controlled by Seed Treatments and Directions for Applying Same

Crop and kind of smut	Disinfectant	Quantity, strength, or temperature	Duration of treatment
Wheat:			
Stinking smut (bunt)	Copper carbonate	2 to 3 ounces per bushel	Mix until each kernel is coated with the dust.
Flag smut	do	do	Do.
Loose smut	Hot water	129° F.	Soak 4 hours in cold water, dip in water at about 120° F. for a moment, then soak 10 minutes at 129° F. (modified method).
Do	do	120° F.	Soak 1 hour and 35 minutes (single-bath method).
Rye:			
Stem smut	Formaldehyde	1 pint in 40 gallons of water	Soak 10 to 30 minutes.
Do	Copper carbonate	3 ounces per bushel	Mix until each kernel is coated with the dust.
Barley:			
Covered smut	Formaldehyde	1 pint in 40 gallons of water	Soak 30 minutes.
Do	Mercurichlorphenol or mercurichlorcresol.	1 ounce in 3 gallons of water	Follow recommendations on package.
Loose smut	Hot water	126° F.	Soak 4 hours in cold water, dip in water at about 120° F. for a moment, then soak 13 minutes at 126° F.
Do	Mercurichlorphenol or mercurichlorcresol (on 6-rowed varieties).	1 ounce in 3 gallons of water	Follow recommendations on package.
Oats:			
Loose and covered smuts	Formaldehyde	1 pint in 30 gallons of water	Soak 30 minutes or sprinkle thoroughly and cover 2-8 hours.
Do	do	1 pint in 1 pint of water per 50 bushels.	Spray with atomizer and cover 5 hours.
Do	Mercurichlorphenol or mercurichlorcresol.	1 ounce in 3 gallons of water	Follow recommendations on package.
Sorghums:			
Covered kernel smut	Copper carbonate	2 ounces per bushel	Mix until each kernel is coated with the dust.
Millet:			
Covered kernel smut	do	do	Do.

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SMUTS OF WHEAT AND RYE AND THEIR CONTROL

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INTRODUCTION

SMUTS are among the most familiar and destructive of cereal diseases. It is extremely difficult, if not impossible, to estimate accurately the damage caused by smuts. The available estimates indicate that many millions of bushels of grain are lost annually. These losses continue to be large in spite of the fact that for many years methods for the prevention of smuts have been recommended. On the whole, these methods have not proved entirely satisfactory. In addition to using clean seed and employing careful farm sanitation, there is need for simple and effective treatments which cause no seed injury. The recently discovered copper-carbonate dust method used for the prevention of stinking smut or bunt of wheat is an example of such treatment.

Wheat and rye are subject to infection by several smuts, as are most of the grain crops. For convenience, a list of the different smuts of grain crops, with the control treatments for each, is given on the opposite page. These smuts are similar in some respects but different in others. With a few exceptions, each kind of smut is confined to a single crop. Two exceptions are the stinking smut and loose smut of wheat, which also occur on rye. For this reason it is desirable to describe the smuts of the two crops in the same bulletin.

Smuts are caused by minute vegetable parasites known as fungi. Everyone is familiar with the molds on bread. The cottony or moldy growth is a living plant, or fungus. The dark-colored, dusty substance which comes from the mold contains numerous spores or seeds of the mold fungus, corresponding to the seeds of higher plants and to the spores of the smut fungi. The black masses of smut which take the place of heads (black heads) or of the kernels (false kernels and smut balls), or which occur on other parts of the grain plant, are filled with the innumerable spores of the smut fungus. Under favorable conditions these spores germinate and infect plants of succeeding crops and reproduce the smut in them.

The various smuts differ as to the way in which they infect the plant. For instance, loose smut of wheat infects through the flower, while stinking smut is carried on the surface of the mature seed and causes infection after the seed germinates. It is for this reason that different methods of treatment are necessary for their control. Loose smut requires the hot-water treatment, because it is inside the seed where surface disinfectants which control stinking smut can not reach it.

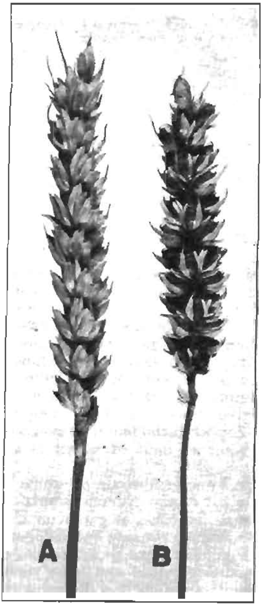

FIG. 1.—A, sound head of wheat; B, bunted head

SMUTS OF WHEAT

There are several smuts affecting wheat, and they appear in the heads or in the leaves. Those discussed in this bulletin are (1) stinking smut or bunt and (2) loose smut, both appearing in the heads; and (3) flag smut, which appears in the leaves.

STINKING SMUT OR BUNT

Stinking smut or bunt is the most destructive of the wheat smuts. In addition to causing losses in the field it renders the sound grain undesirable for milling purposes until it has been thoroughly scoured and washed, which is expensive and results in heavy losses due to dockage. Two species of the fungus, belonging to the genus Tilletia, cause stinking smut. One of these (*Tilletia tritici*) is confined largely to the West, while the other (*T. laevis*) occurs principally in the eastern part of the country. The smuts caused by the two species are so nearly alike that it will not be necessary to discuss them separately.

Wheat plants infected with stinking smut can not be detected with certainty until they have headed. However, there often are signs before heading which indicate that the plants are infected. They may be more or less stunted and have a bluish green color somewhat darker than normal. After the heads form they may have a bluish green appearance. Generally they are distorted or abnormal in shape also. (Fig. 1, B.) The smut balls which replace the wheat kernels may become large enough to spread apart the glumes or chaff. After the crop is mature these smutted heads

appear darker than the normal heads. This is due to the mass of dark, almost black, smut spores which make up a large part of the smut balls. (Fig. 2, B.) When broken open, these smut balls have a disagreeable odor resembling that of decaying fish; hence the name "stinking smut."

During harvesting and threshing many of the smut balls are broken and the spores are thoroughly mixed with the sound wheat. If this wheat is sown for seed without treatment, the smut spores germinate as the wheat germinates. The minute germ tubes produced by the spores cause infection by entering the young wheat plant and growing up through its tender tissues as the plant grows.

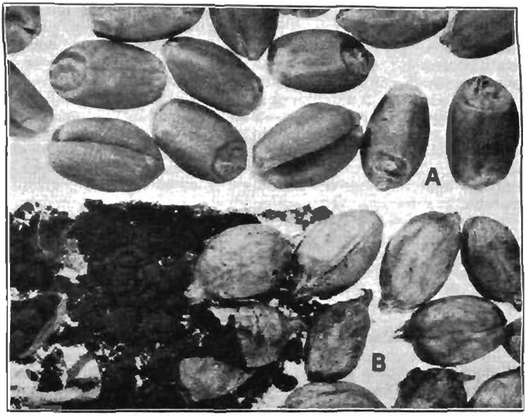

FIG. 2.—Stinking smut or bunt of wheat. A, Sound wheat; B, stinking smut

The fungus thus finally enters the heads and produces spores in smut balls which take the place of normal wheat grains.

In the Pacific Coast States, where dry weather prevails through the summer, wheat is infected also by stinking-smut spores which live in the soil from harvest time until the seed is sown for the next crop. Infection takes place in the same way as if the spores were carried on the seed. Soil infestation is not generally important east of the Rocky Mountains. In the Palouse district of eastern Washington, northwestern Idaho, and northeastern Oregon, seed treatments which are satisfactory elsewhere are less effective because of the general soil infestation. Stinking smut is so abundant in this area that during the harvest and threshing season, when the weather generally is dry, clouds of smut spores are blown over the country from harvesting and threshing operations. (See illustration on cover page.) These spores may be carried many miles. Even virgin land will not be free from infestation, as the spores are

distributed everywhere. The infestation will be heavier, of course, to leeward of threshing machines and near fields of heavily smutted wheat. The spores have a tendency to settle in greater abundance on the leeward side of hills. Smut explosions in threshing machines in this area often are followed by fires which cause considerable property damage.

CONTROL MEASURES

Several measures are being practiced for the prevention of stinking smut. Among these are the selection of smut-free seed, seed treatment, certain cultural methods, and the growing of smut-resistant wheats. Smut-free seed and seed treatment are effective where there is no soil infestation. In the West, where soil infestation is important, neither of these measures is entirely satisfactory. Certain seed treatments prevent a large part of the infection but do not completely control it. Crop rotation and the use of spring wheats following thorough cultivation of summer fallow in the fall have been practiced to a certain extent. A large percentage of the spores in the soil die during the winter under this kind of cultivation. It has not proved practicable, however, to replace the winter wheats with spring varieties. Early sowing of winter wheat while the soil is still warm affords some protection from bunt infection, due to the fact that relatively low temperatures, from 45 to 60° F., are most favorable to infection. This early sowing is not always practicable, however. The most satisfactory means of control in this area is the growing of smut-resistant wheats if desirable varieties can be developed. The use of resistant varieties, if these are available, would be more desirable than other measures, even where soil infestation does not occur.

Copper-Carbonate Dust Treatment

In recent years the copper-carbonate dust treatment has come into use for the prevention of stinking smut. It is the most popular treatment yet known for the control of this smut. It is just as effective in most cases as the copper sulphate-lime and the formaldehyde treatments and is more satisfactory in the following respects: (1) It does not injure germination; in fact, treated seed often germinates better than untreated seed; (2) seed can be treated whenever convenient and stored without injury, a practice which is impossible when the wet methods are used; (3) dusted seed can be sown at any time in either dry or moist soil; (4) very little labor or expense is required in treating seed for large acreages; and (5) copper carbonate protects stored grain from weevils and also from rats and mice if there is untreated grain in the storehouse on which they can feed.

Copper carbonate that is manufactured especially for seed treatment should be used. Two types are obtainable, and there are different brands of each. One type contains about 52 to 55 per cent of metallic copper and is known as pure copper carbonate. The other type contains about 18 to 26 per cent of copper and is known as the "diluted" form. Where soil infestation is abundant as in the Pacific Northwest, the latter form has not proved as satisfactory in some instances as the pure copper carbonate. Where no soil

Two ounces of copper carbonate per bushel of wheat has proved sufficient in most cases. As much as 3 ounces is recommended when the seed or the soil is heavily infected. This is especially true if the "diluted" form is used. If conditions are such that more than 2 ounces is needed, 2½ or even 3 ounces may be used. An excessive quantity of copper carbonate is not likely to injure the seed, but it may lead to severe injury to the drill.

Copper carbonate, to be effective, must completely cover the seed. Each kernel must be entirely coated with a thin film of the dust. The best way to obtain a thorough application of the dust is to mix it with the grain in some kind of rotating machine, or barrel mixer, until each kernel is completely covered with the dust. This should not require more than one or two minutes, depending on the type and speed of the machine. The mixing of wheat and copper carbonate by shoveling over the seed on the floor is not recommended because so much of the dust gets into the air. If inhaled by the operator, it will cause irritation and even nausea. A dust mask or a wet handkerchief should be worn over the nose and mouth while the wheat is being treated, even when the machine mixer is used. Under no circumstances should the mixing be done in the hopper of the grain drill.

CAUTION

Copper-carbonate dust is a poison and is very irritating to the lining of the nose and throat. It may cause severe nausea.

Use a gas mask or a wet handkerchief tied over the nose and mouth to prevent the inhaling of the dust while treating grain. This should be done even when the machine mixer is used.

Copper is poisonous to human beings. Do not sell for milling purposes any grain which has been treated for use as seed.

If possible, do not use badly smutted seed. If it is necessary to sow heavily smutted seed in infested soil, it is better to use the copper sulphate-lime or the formaldehyde treatment (see table facing page 1) instead of the copper-carbonate dust.

Copper carbonate will not control the loose smut of wheat and rye, nor the smuts of oats, barley, and corn.

Copper-carbonate dust may cause real injury to the drill. To avoid trouble of this kind observe the precautions noted on page 9.

There are several commercial mixing machines which are satisfactory for treating seed with copper carbonate. A mixing machine also may be made on the farm at a very low cost. A concrete mixer,

an old barrel churn, a water-tight barrel, or a steel oil drum can be used very satisfactorily for making a mixing machine at home. The following descriptions will show how to build a mixer of each type.

BARREL MIXER

Many modifications of the barrel mixer have been made for treating wheat with copper carbonate. It would be difficult to construct a machine which would be satisfactory to everyone. The following description of a very satisfactory home-made barrel mixer (fig. 3) was furnished by F. W. Oldenburg, of the Maryland University Agricultural Extension Service.

Cut an opening across two wide staves in the side of a 30 or 40 gallon barrel made to hold liquids, making a door hole approximately 8 by 14 inches. It may be necessary to remove the inside hoops in order to do this. The staves should be sawed at an angle, leaving a beveled edge to the door, which will be wider at the outside than at the inside. (Fig. 3.) To prevent the escape of the dust the edges may be lined with rubber from an old inner tube of an automobile tire. To insure a well-fitting door, the parts of the two staves which are to form the door should be hinged and fastened together, as shown in the illustration, before they are sawed out. A revolving latch is convenient for holding the door in place when shut.

Preliminary to the construction of an axle and crank, a railing flange, threaded to fit a 1-inch pipe, is screwed to each end of the barrel at the center. The axle and crank are composed of two pieces of 1-inch pipe and two pieces of ½-inch pipe, each piece 6 inches long and threaded at both ends, and two 1-inch by ½-inch reducing elbows. The two pieces of 1-inch pipe are screwed into the flanges on the barrel to serve as an axle. A crank is made from the other two pieces of pipe and the elbows, as shown in the illustration.

If the door is a foot or so wide it is possible to insert a mixing board about the full length of the barrel, to prevent the sliding of the wheat in the barrel and to aid in the mixing. The board should be about 1-inch thick and 9 inches wide, and should be securely nailed edgewise to the inside of the barrel opposite the door. If desired, it may be curved on one edge to fit snugly against the barrel wall.

The barrel is then mounted on a convenient base or stand. That shown in Figure 3 has proved very satisfactory. Sawhorses about 34 inches high and 3 feet long also are satisfactory for this purpose. Bearings for the axle can be made by driving two large nails into the sawhorses, one on each side of the axle, and applying a little axle grease to the axle. If a special stand is constructed, it should be free from inside braces so that a basket or a tub may be placed under the barrel to receive the wheat after treatment.

OIL-DRUM MIXER

The following description of an oil-drum mixer (fig. 4) was furnished by R. S. Kirby, extension pathologist, Agricultural Extension Division, Pennsylvania State College. The machine is constructed so that it produces a double action when in motion. It rolls and throws the wheat against a mixing board in addition to sending it from end to end of the drum or barrel.

A 30-gallon oil drum is a convenient size. One-half of one head of the drum is cut out. A strip of board 1 inch thick, 6 inches wide, and the proper length to fit snugly against the inside of the rim of the barrel (about 17½ inches) is bolted to the remaining half of the head so that about 1 inch of the edge of the steel head extends beyond the board. A semicircular wooden head is next cut to fit snugly the open half of the drum head and is hinged in the center to the 6-inch strip so that it will open. If this head does not have a dust-tight fit a strip of old inner tube can be nailed around the edge. A hinged hasp is attached to the door to hold it shut and to force it tightly against the edge of the drum when closed.

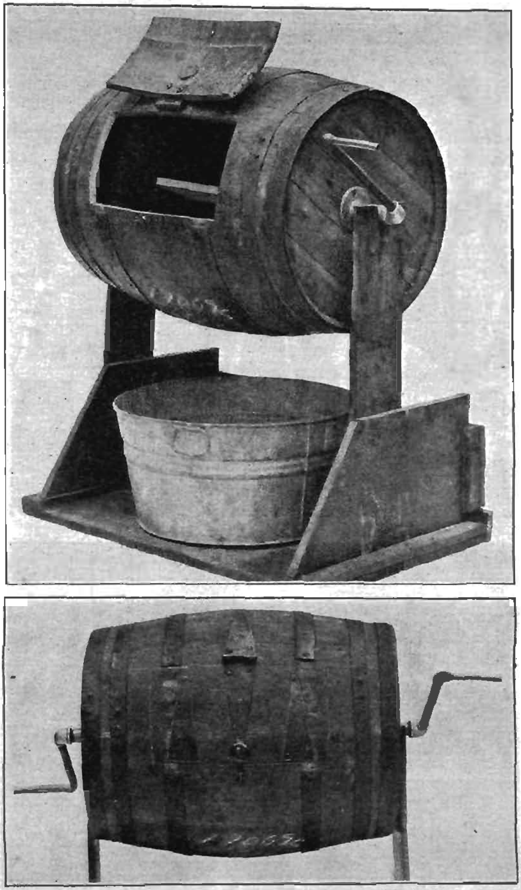

FIG. 3.—A barrel mixer for treating wheat with copper-carbonate dust. In the upper view note mixing board inside the barrel, the beveled door and door frame, and the railing flange for attaching a handle to the barrel. The lower view shows the construction of the door and the handles on both ends of the barrel

LOOSE SMUT

Loose smut of wheat, commonly known simply as "smut" or "blackhead," is different from stinking smut and flag smut, the other two smuts of wheat. As soon as the wheat heads out, the smut is very noticeable. (Fig. 5.) The diseased heads are almost completely destroyed by the smut. Instead of normal wheat chaff and flowers, black masses of smut, composed of the spores or seeds of the smut fungus, *Ustilago tritici*, appear along the axis of the head. The spores are easily shaken from the smutted heads and may be carried for long distances by the wind or by insects or other agencies. This distribution of loose-smut spores takes place most abundantly at about the time the healthy wheat is in bloom. (Fig. 6.) Some of the spores may lodge between the glumes or chaff of the sound wheat heads, where they germinate and grow into the very young wheat kernel inside the chaff. The infected kernels are not destroyed by the fungus, as in the case of stinking smut. Instead, the fungus remains dormant inside them while they are developing. Smutted kernels can not be distinguished from smut-free kernels when mature. However, if this wheat is used for seed without treatment, the smut fungus inside the seed starts growing as the kernel germinates, and spreads upward into the tender tissues of the plant as it develops. Finally when the wheat heads appear they are composed of the smut masses described above.

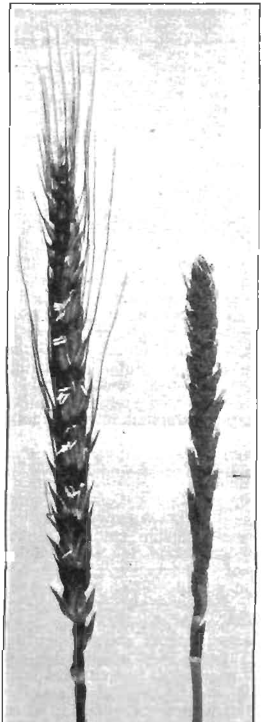

FIG. 5.—The appearance of loose smut in wheat when the sound heads are in bloom

Because of the fact that the smut fungus is carried inside the seed, it is necessary to apply a treatment sufficient to kill it under these conditions. Surface disinfectants which control stinking smut and other surface-borne smuts, therefore, will not control loose smut. The hot-water treatment is recommended for the control of this disease. If the treatment is properly applied, the heat penetrates

the seed and kills the dormant fungus without killing the wheat germ, since the wheat will endure higher temperatures than the smut fungus.

There are possibilities also of controlling loose smut by growing varieties of wheat which are resistant to it.

HOT-WATER TREATMENTS

Two different hot-water treatments have been devised, one known as the modified hot-water treatment and the other as the single-bath hot-water treatment. In the former method the seed is presoaked for four hours in cold water, dipped in water at about 120° F. to warm the seed, and then soaked for 10 minutes in water at 129° F. In the single-bath method the long presoaking in cold water is omitted, and the seed is soaked for 1 hour and 50 minutes in water at 118.5° F. or for 1 hour and 35 minutes at 120° F. In the 10-minute bath of the modified treatment, and throughout the single-bath treatment, care should be taken to maintain the recommended temperatures as closely as possible.

FIG. 6.—Loose smut of wheat as it appears after the sound heads have begun to fill

In both the modified and single-bath treatments the soaking of the seed causes it to swell considerably. The sacks used in treating the seed, therefore, should be only half filled and tied at the top. Care also should be taken to keep the seeds from caking in the sacks during the treating process. After treatment, the seed should be raked out in a thin layer to cool and dry. It is safer to sow the seed after it has thoroughly dried, but it will run freely through the drill as soon as it is surface dry, when it may be sown. In the latter case the drill should

be set at a higher seeding rate to allow for the swollen condition of the grain. Seed which is only surface dry still contains enough moisture to cause germination in a dry soil. If sown in dry soil, some of the seedlings may die, and the stand may be severely injured.

Neither of the hot-water treatments is recommended for treating seed for the entire crop, because they are difficult to apply and often cause injury to the seed, particularly when the seed coats have been broken in threshing or otherwise. If seed from smut-free fields can not be obtained, it is best to treat only sufficient wheat for sowing a seed plot, and the farther this plot is isolated from fields of untreated wheat the better. The crop grown on the isolated seed plot from treated wheat and successive crops from the same seed lot may remain relatively free from smut, so that further seed treatment will not be necessary over a considerable period. However, reinfection of the seed in the seed plot may take place rapidly. The amount of smut in near-by fields and the influence of climatic factors on its spread and on its development in the wheat flower doubtless play an important part in this reinfection. If the wheat to be treated for loose smut is infested also with stinking smut, the hot-water treatment will control both, but the copper-carbonate treatment recommended for the control of stinking smut will not control the loose smut.

In Indiana, community seed-treating plants established in recent years have proved very satisfactory for applying the modified hot-water treatment. Usually they are managed by the county agricultural agent or by a group of neighborhood farmers. Through the use of treated seed and seed produced by crops from such seed a number of relatively smut-free areas of considerable size have been established in Indiana under the community treating-plant system. The beneficial effects of treatment are made more lasting in this way, as the fields within the smut-free areas are mutually protected from infection.

RESISTANT VARIETIES

The important wheat varieties of the eastern United States and a few of the most important varieties of the western United States now have been tested for resistance to loose smut during two or more years. Thousands of individual wheat flowers have been inoculated by hand in order to insure infection. As a result, one or more highly resistant or immune strains have been found in the following varieties: Preston (hard red spring common wheat); Blackhull, Hussar, Ridit (hard red winter common wheats); Forward, Fulcaster, Fultz, Gipsy, Harvest Queen, Leap, Purplestraw, Russian, Trumbull, Wyandotte (soft red winter common wheats); and White Winter (white common wheat). These strains have not yet been tested for yield and quality. If they prove satisfactory in these respects, doubtless they will become valuable assets in reducing the losses caused by loose smut. Some of the commercial varieties containing resistant strains, Fultz and Fulcaster for example, are among the most widely grown wheats east of the Mississippi River.

FLAG SMUT

Flag smut of wheat was discovered in the United States in Missouri in May, 1918. The disease is known to cause heavy losses in

the wheat crops of Australia and China. It also occurs in Japan, India, South Africa, Italy, and Spain. The United States has a quarantine against importations of wheat from all foreign countries where flag smut is known to occur. The disease is confined to a limited area in this country but is well under control; therefore it is advisable to prevent its introduction into other sections of the country.

Since 1918 flag smut has been found in three counties in Missouri near St. Louis, and in several adjacent counties in Illinois, and also in several counties in northwestern Missouri and northeastern Kansas near Kansas City. The disease has not caused much loss in the infested areas, usually not more than 1 per cent of the plants being infected. In parts of some fields, however, infection has been much heavier.

Flag smut appears as black stripes running lengthwise in the leaf blades and sheaths of the wheat plant. (Fig. 7.) In the early stages the stripes are somewhat lighter than the green color of the normal leaf, but later they become lead colored and finally black. The stripes then are filled with the dark-colored spores of the fungous parasite, *Urocystis tritici*. The black stripes may be seen in the leaves, especially the upper ones, before the jointing of the plants begins. Often they may be seen in the stems also. Infected plants usually are more or less dwarfed. The leaves and sheaths frequently are twisted, and the diseased plants rarely produce heads. Sometimes normal heads are developed on smutted plants, but usually the entire plant is affected, and no sound heads are produced. Where heads appear on infected stems the black stripes may be

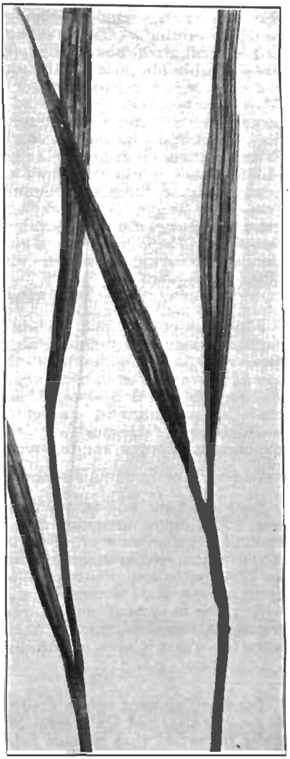

FIG. 7.—Flag smut of wheat. The smut is contained in the black stripes in the leaves

present on the chaff at the base of the head and usually are present on the stem just below the head.

Although the flag smut of wheat resembles the stem smut of rye, it is caused by a different though closely related fungus. The organism causing flag smut of wheat will not infect rye, nor will the organism causing stem smut of rye infect wheat.

The small, dark-colored smut spores or seeds of the fungus, which are formed in the spring in the wheat plant, may become attached to the wheat kernel in harvesting and threshing or may fall on the soil. They may be blown by the wind or carried by water, or by other means, such as threshing machines or other farm implements and by man and animals, for considerable distances from the infected plants. When smutted wheat is sown or when clean seed is sown in infested soil the smut spores germinate as the wheat germinates, and the young wheat seedlings are penetrated by the minute, threadlike germ tubes of the fungus. After entering the seedling these fungous threads grow up through the tissues of the wheat plant, from which they obtain food. They live in the plant until spring, when they begin to produce the dark-colored spores which are seen as black stripes in the older wheat plant.

CONTROL MEASURES

Flag smut may be held in check and reduced in quantity by judicious quarantine, seed treatment, crop rotation, and other sanitary measures, and by growing resistant varieties of wheat. The percentage of infection also is influenced by soil and weather conditions at the time the wheat is sown. Quarantine and sanitary measures include the regulation of shipments of infected grain and straw, the disinfection of farm machinery, etc., when leaving the infested area, the burning of straw, and the treatment of seed grain.

Seed Treatment

Seed treatment will destroy the spores of flag smut carried on the seed. The copper-carbonate dust treatment recommended for controlling stinking smut of wheat is the most satisfactory treatment. None of the seed treatments prevent infection of wheat seedlings by flag-smut spores present in the soil. Spores will live in the soil from harvest until seeding time, and have even been found to live over winter in parts of smutted-wheat plants buried in the soil. Seed treatment, therefore, can not be depended on to control the disease when the wheat is sown on infested land.

Sanitary Measures

Because flag-smut spores easily survive in the soil from harvest to seeding time and are present to infect fall-sown wheat, it is especially important that infested fields be sown to other crops the following year unless a resistant wheat is used. The continuous growing of susceptible wheat on infested land may result in an increase of the disease, as has been found to be the case in Australia. Flag smut affects only wheat, therefore other crops may be grown safely in the rotation. Any material that may contain flag-smut spores, such as straw, manure, or a straw mulch on potatoes, may serve as a source of infection when applied to the land. For the best results

infested crop residues and manures should not be returned to the soil. If they are used, the safest place in the rotation to apply such material is on the wheat stubble before a nonwheat crop.

Varieties

The use of resistant wheats promises to be the most satisfactory means of controlling flag smut. Numerous varieties of wheat have been collected and the seed heavily smutted and then sown in the infested area in Illinois, in order to subject them to conditions highly favorable for infection. Several varieties have remained either free from or highly resistant to flag smut for a number of years. Some of these wheats are commercially desirable and are being sown without treatment in the infested area.

Among the resistant wheats being grown commercially in the flag-smut area are Shepherd, Trumbull, Gladden, and Fulhio. A few resistant selections of Red Cross and Harvest Queen have been found. There are other highly resistant wheats which are less adapted to the infested area.

The wheats grown commercially in the infested area which are susceptible and should not be sown there are Flint (May), Fultz, Harvest Queen (Salzer's Prizetaker, Red Cross), Jones Fife, and Red Wave. If these susceptible varieties are replaced by the resistant wheats in the infested area no serious losses are likely to result from flag smut.

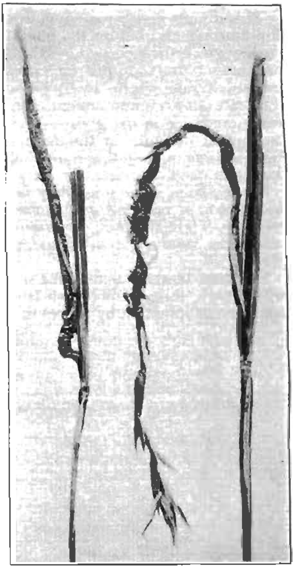

Fig. 8.—Stem smut of rye

SMUTS OF RYE

Rye is subject to three smuts. Two of these—stinking smut and loose smut—are caused by the same species that cause those diseases in wheat. On rye they look very much like the stinking smut and loose smut of wheat. These smuts are seldom found in rye, however, and are not considered of sufficient importance to warrant seed treatment or other control measures. If they should increase sufficiently to become destructive in rye, the same treatments recommended for

wheat probably can be used, namely, copper carbonate for stinking smut and the hot-water treatment for loose smut.

STEM SMUT

The third and most important of the rye smuts is stem smut, caused by a fungus, *Urocystis occulta*, closely related to that causing flag smut in wheat. The stem-smut fungus will not infect wheat, however, nor will the flag-smut fungus infect rye.

This disease first becomes evident when the stems or culms shoot up for heading and before the heads are out. Infected plants appear darker green than normal, and the infected parts often are distorted and may twist and split in various ways. (Fig. 8.) Long lead-colored streaks which finally become black are typical of stem smut. The streaks are more common on the stems, but may occur in the leaves and also in the glumes or chaff of the head. The plants may be stunted so badly by the disease that they are scarcely noticed at harvest time, and it therefore is difficult to estimate the amount of damage caused by this smut.

Spores from stem smut may be carried on the seed from an infested crop or may fall to the ground and remain alive until the next crop is sown in the fall. Spores either on the seed or in the soil will infect the young rye seedlings and cause them to produce smutted plants.

The same treatments used for stinking smut and flag smut of wheat will prevent stem smut of rye from seed-borne spores, but they will not prevent infection by spores in the soil.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

November 10, 1927

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